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UNITED STATES DEPARTMENT OF AGRICULTURE
Bureau of Agricultural and Industrial Chemistry
Agricultural Research Administration
Washington, D. C.

Bureau Conference on Fruit Concentrates
Winter Haven, Florida.
May 7 and 8, 1951

On May 7 and 8, 1951, a Conference, at which representatives of this Bureau were present, was held at Winter Haven, Florida. The primary purpose of the Conference was to discuss the present status of fruit concentrates, what lines of research it seemed advisable for the Bureau to undertake in this field, present status of research and the exchange of information and ideas between the different leaders engaged in research projects in the field of fruit concentrates.

Attached is a record of the discussion during the meeting. The record does not constitute a verbatim transcript of the entire conference. This was impossible because a skilled stenographer was not present. It is believed that the transcript presented represents the more important aspects. Following is a summary of the facts brought out:

At the present time, no one is commercially producing frozen pineapple concentrate in the Continental United States. Hawaiian Pineapple expects to be in production soon, and Mojonnier is building a concentrate unit in Cuba. Texas Frozen Foods, Harlingen, has a pilot plant and is working in cooperation with Minute Maid, Plymouth, Florida.

Frozen tomato concentrate is being packed by two companies. Hot process low temperature concentrate is said to taste better than frozen low temperature concentrate. If heat processed, tomato concentrate must be labeled "tomato paste" or "puree." Frozen tomato concentrate can be labeled as such if it is not pasteurized, according to the Federal Food, Drug, and Cosmetic Act. Restoration of recovered essence does not seem desirable with tomato concentrate.

Frozen grape concentrate is being put out by four companies. Some add citric acid, sugar and certain other additives. There is some question as to the advantages of frozen grape concentrate over high-density concentrate. High Brix grape concentrate is a self-preserving product and is not pasteurized and has no off-flavors. There is a slight loss in essence on one year's storage, but in general is a very satisfactory product. Hot packing is not necessary, because the juice is effectively pasteurized by essence stripping, and high sugar content makes it self-preserving.

An experimental pack of frozen apple concentrate was produced at the Western Regional Research Laboratory for market tests carried out by the Bureau of Agricultural Economics. A West Concord, Massachusetts, firm is making frozen concentrated apple juice containing essence. The product has a light color. It was said that light colored juice was not selling so well

as the darker color and more highly flavored product. A 7-fold concentrate with essence was initially nearly as good as frozen concentrate with essence, and the advantages of reduced bulk are obvious.

There are plenty of plants producing frozen citrus concentrates, and the limitations are in price and marketing, not production. Evaporators making this concentrate operate from 60° to 84° F. Pilot plant production at the U. S. Citrus Products Station at Winter Haven showed a flavor difference in juice concentrated at 60° and that at 80° F., but no difference could be detected between juice concentrated at 60° and that at 70° F. There is little or no lime concentrate produced in Florida, and probably 50% of this year's California lemon crop will be processed. It is claimed that consumers on the average buy one 6-oz. can per person per month of frozen concentrated orange juice, and the number of people buying frozen concentrate is the same as three years ago. Probably only 1.3% of the population buys frozen citrus concentrate. Frozen grapefruit concentrate is not going as well as it was hoped. The public apparently does not think the difference in quality between frozen concentrate and canned single strength juice is worth the price difference.

Considerable research has been done on the flavoring constituents of California Valencia oranges and Marsh Seedless grapefruit. The work seemed to indicate that the flavor factors in citrus were not in the water fraction stripped from the juice, but that all flavor contributing constituents were ether soluble. There is an oil in the sacs of the fruit, which is not soluble in the juice and is not associated with the oil of the peel. Since the amount of oil in the sacs is very small, it is believed that most of the oil commonly present in the cut-back juice must come from the peel. It is said that it is from this source that most of the oxygenated constituents that contribute to the characteristic orange flavor are derived. The flavor of orange juice is thus in the peel oil. Experimentally, orange juice has been concentrated to 43° Brix and a good orange oil added to yield a product as good as a concentrate made with cut-back juice. However, not all peel oils are satisfactory for this purpose, and it is not known what characteristics are necessary in a peel oil to make it satisfactory for this purpose. The amount of oil added can be controlled to give a product of any desired oil content to meet a given market. It is not known whether the addition of essence to grapefruit juice would be advantageous. Nor is it known whether the addition of essence to frozen pineapple concentrate is desirable.

There was considerable discussion relative to the steam injection methods of the Western and Eastern Regional Research Laboratories. The steam injection method of the Western Regional Research Laboratory has three basic advantages: (1) There is no heat exchange surface, (2) it will handle purees, and (3) it has considerable speed in heating and cooling. There is no disagreement between the Eastern and Western Regional Research Laboratories relative to the two types of preheaters developed in the separate laboratories. Each type has its own field of usefulness.

The question of fouling of heat transfer surfaces was discussed. Turbulence and a velocity of at least seven feet per second travel are essential in preventing fouling of heat transfer tubes with apple juice.

The significance of Internal Revenue regulations on ethyl alcohol in relation to fruit concentrates was brought up. Since grape juice is aged for several months, the juice may contain 0.25% alcohol. When this juice is concentrated 4 to 1 and the essence returned, the alcohol is raised to such

a point that it would carry a $9.00 per gallon tax. Where sugar is added in the preparation of frozen grape concentrate, it probably reduces the alcohol to below 0.5%. The Bureau might get an expression from Internal Revenue on this subject.

In regard to concentration by freezing, some attempts have been made in Florida in this field. The Commonwealth process is being tried out at the Sperti plant in Orlando, Florida, but nothing has been heard of the results. It is said that 3-fold concentration is as far as one may economically concentrate. Theoretically, the process should be of interest, for about seven times as much energy is required to evaporate a pound of water as is required to freeze it. But considerable mechanical difficulties are encountered. Further, inasmuch as the flavor of citrus juices is largely associated with the suspended matter, a great deal of this suspended matter is trapped in the ice and lost during centrifuging. There may be interesting possibilities in the German Gümbel process, which involves concentrating the juice by freezing until the desired concentration is obtained and then removing the concentrate by downward displacement. At present, freezing concentration does not seem to offer much promise with citrus, but application to other products may have possibilities.

Optimum concentration temperatures for some fruit products were pointed out. For apple juice, 120-130° F.; orange, 80° F. or below; grape, 114° F. for one hour is probably satisfactory. A little heat seems to improve grape concentrate. It was said that the product would stand 160° F. for 2 hours; damage is apparent at 175° F. Tomato concentrate is not very heat sensitive and, in fact, flavor seems to be improved by heat treatment. Nothing is apparently known regarding heat sensitivity of pineapple concentrate.

Florida producers have suffered losses from unstable citrus concentrates that gel or clarify. It was brought out that there has been no gelation in California citrus concentrates.

Aspectic canning methods are becoming of interest in Florida. One processor has a pilot plant to try the Martin Method. It was thought that Bureau researches in this field should, perhaps, be confined to products that need such a process, rather than to those products satisfactorily processed by present methods.

Problems involved in the preparation of dehydrated orange juice are (1) caking, (2) browning, (3) changes in carotenoid pigments during storage, (4) reincorporation of volatile flavors. Browning and caking during storage at 100° F. are greatly reduced by the use of additives such as methocel, corn sirup solids and by in-package desiccation. Orange oil may be added to the feed, to the spray dryer and sufficient oil retained during drying to impart satisfactory flavor to the reconstituted juice.

Possibilities of obtaining other dried fruit juices, such as pineapple, lemon, and grape, may be of interest for the preparation of fruit drinks and jellies. Spray dried apple juice has been prepared at the Western Regional Research Laboratory without injurious flavor change other than loss of essence. Corn sirup solids were used as a spreader.

Citrus concentrates seem to be the only concentrates benefited by frozen storage. Cold storage is sufficient for grape and apple concentrate. We do not know about pineapple concentrate. The storage of citrus concentrates has been studied at both the Winter Haven, Florida, station and the Pasadena laboratory. Storage of apple concentrates has been studied at the Eastern and Western Regional Research Laboratories. After 6 months' storage at 100° F., the concentrate (44° Brix) was very dark and entirely unacceptable. Even at room temperature, 4-fold apple concentrates will not keep. Storage of tomato concentrates will be studied at the Pasadena laboratory and at the Western Regional Research Laboratory.

Chance of obtaining citrus concentrates of greater than 30 to 40° Brix that will be stable at room temperatures are not encouraging because of the browning reaction. But it is probably possible to get grape and tomato concentrates that would keep at room temperature.

Studies concerned with flavor deterioration in citrus juices were reviewed, particularly the research on lipids, pectins, oils, amino acids, flavenoids, carotenoids and enzyme activity.

The sanitary significance of E. coli in frozen fruit concentrates should be given the same significance as we now do to E. coli in milk. E. coli do not live long in citrus concentrates at 0° F. storage, and have a shorter life at higher temperatures. Dr. Patrick has never found E. coli in commercial Florida frozen concentrated orange juice. There is a great deal of difference of optimum regarding the identification of E. coli. The most serious microbial contamination of citrus concentrates has come from kick-back from the condensers due to surging in the evaporators. It has been found that in some cases of off-flavor and aroma, that often contamination skips. Cases of good concentrate will be produced intermittently. It has been found that Leuconostoc is associated with the off-flavor and aroma. Leuconostoc will grow in dilute juice, and high populations of these organisms have always been associated with off-flavors.

In regard to total bacterial counts, it was brought out that we are not so interested in total count as we are in types or groups of organisms present. There is no universally suitable medium for making counts. Attempts are being made to find a method for direct counts which would be a valuable tool for the citrus processing industry.

Inasmuch as other fruit concentrates are pasteurized in the process of essence stripping, bacterial count of such concentrates is probably not of importance. An exception is the freeze concentration of apple juice.

Stream pollution was discussed. Florida State health authorities are getting more belligerent and have indicated that they had ample authority to close citrus plants - but they did not intend to do so. There are at present some experimental trickling filters being used at some of the plants. Effluents are also being discharged on waste, well-drained land, or in Gulf-side plants, into the Gulf. In Texas, the freeze has probably eliminated the waste disposal problem for the next five years. Experiments in disposal have been carried on intermittently in the Valley since 1937 by the Texas Department of Health, Texas and National Canners Association, and U. S. Public Health Service. Activated sludge and trickling filters have been tried, but most

promising seems to be lagooning with sufficient nitrate to support algae.

It is said that there is no problem in California. The practice around Los Angeles is to dump the effluent into the city sewage system. Plants not on city sewage have successfully lagooned on several hundred acres of land.

Since U. S. Public Health Service has funds for work of this nature, it was believed that organization should undertake such investigations rather than the Bureau.

Detailed Notes on Bureau Conference on Fruit Concentrates*
Winter Haven, Florida, May 7 and 8, 1951

Acting Chairman, H. W. von Loesecke

von Loesecke: You will notice from the Agenda that the names of certain individuals are mentioned as discussion leaders under each question to be asked. This does not mean that discussion is limited to those individuals, and if anyone else not mentioned has anything to contribute, feel free to speak up. Our first question is:

What are the present commercial trends in the production of frozen concentrates?

I might mention in this connection that the Quartermaster Corps desires to know who produces pineapple concentrate, because they are making up specifications and want to obtain samples of the product..

Eskew: I understand someone near Tampa produces pineapple concentrate.

Veldhuis: I don't know who it could be. Minute Maid at Plymouth is not at present producing pineapple concentrate.

Talburt: Hawaiian Pineapple Company will soon be in production. There have been several announcements in trade journals regarding this.

Beavens: I understand some is being put up in Cuba.

Scott: Texas Frozen Foods, Harlingen, has a pilot plant and is working with Minute Maid.

Patrick: Mojonnier is building a unit for the production of pineapple concentrate in Cuba.

von Loesecke: Several years ago, Sun Dine at Lake Alfred had trouble with specks in single strength juice and stopped production. They also had a great deal of trouble with cans blowing up.

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*Before these notes were issued in final form, all those participating in the conferences were supplied copies so that they could make necessary corrections. These notes are not a verbatim transcript of the entire conference.

Kew: The "bugs" were bugs that get inside the fruit and were not successfully removed without removing the pulp.

Keller: C. E. Howard Company of Los Angeles builds essence units for double and triple effect evaporators, but their effectiveness is not known.

von Loesecke: As of now, nobody is in commercial production in the Continental United States, I gather. What is the story on tomato concentrate?

Keller: Tomato concentrate must be labeled tomato paste or puree, if heat processed.

von Loesecke: The Food and Drug calls it Tomato Paste. The frozen product can go as frozen concentrate, but hot pack is defined as paste or puree. If it is not pasteurized, it does not come under the regulation.

Panel: Two companies pack frozen tomato concentrate. They do not use high vacuum; moderate heat evidently.

Beavens: Hot process low temperature concentrate tastes better than frozen low temperature concentrate. The Quartermaster Corps has specifications out for 3-1/2-fold hot process concentrate. There are no P.M.A. grades or Food and Drug standards of identity yet for frozen tomato concentrate. Even the frozen concentrate is "hot break" - 1 to 2 minutes. This results in complete pectinesterase destruction.

Panel: Consensus of Pasadena group was that restoration of essence was not desirable in tomato concentrate. Flavor is improved through loss of aroma during concentration.

von Loesecke: What about grape concentrate? I understand that at present there are four producers.

Talburt: Sunshine, I know, makes label declaration of citric acid, sugar and other additives.

von Loesecke: Quartermaster is interested in both frozen and not frozen grape concentrates.

Eskew: What advantage has the frozen grape juice concentrate over high-density concentrate? [Grape concentrate deteriorates when stored at room temperature.] High Brix concentrate is a self-preserving product and is not pasteurized, and has no off-flavors. There is a slight loss in essence on one year's storage, but in general it is a very satisfactory product. The Eastern Regional Research Laboratory has made high-density (68° Brix) concentrate containing essence. It compares favorably with single strength juice, stores well at 35° F. for a year with no off-flavor and only slight essence loss. Hot packing is unnecessary, because the juice is effectively pasteurized by the essence stripping, and high sugar content makes it self-preserving.

von Loesecke: Are there any standards for grape concentrate at present?

Phillips: No. Some people like the pure strong grape juice flavor, while others like the less strong flavor as made by dilution or addition of sugar or both.

Beavens: How is grape juice detartrated?

Eskew: Juice is pasteurized and stored in very large stainless steel or wood tanks, or in 5-gallon bottles, cooled to allow precipitate to form, followed by decantation and repasteurization.

_____ The standards for acidity have been reduced from .8 to .6 percent.

von Loesecke: What about apple concentrate?

Talburt: 40,000 6-oz. cans were produced at the Western Regional Research Laboratory for a 10-weeks market test in Modesto, California, and Tyler, Texas. There was radio, newspaper and other advertising. The Bureau of Agricultural Economics is to make a survey as to repeat sales on completion of market tests. Current indications being orange and apple selling in the ratio of 4 to 1. Apple is selling a little faster than grape. The apple concentrate in this test was a blend of 55% Delicious, 25% Winesap, 15% Jonathan, 5% Rome Beauty, plus citric acid (.07 to .08 percent) to make a total acidity of .4 percent.

von Loesecke: Citric acid is in short supply at present, and is being allocated by Pfizer to their customers.

Talburt: Malic, lactic, hydrochloric, and phosphoric acids have been used in some laboratory experiments. A West Concord, Massachusetts, firm is making frozen concentrated apple juice containing essence. They add ascorbic acid, which increases cost and may require consumer education to accept its light color and less robust flavor.

Brown: The light colored juice (with added ascorbic acid) is not selling as well as the darker colored and more highly flavored product.

Eskew: A 7-fold concentrate with essence was initially almost as good as frozen concentrate with essence. The advantages of reduced bulk are obvious. It stores satisfactorily for a year at 35° F. Hot pack is unnecessary - reason, same as for high-density grape.

von Loesecke: What is the picture on citrus concentrates?

Veldhuis: Now there are plenty of plants, and the limitations are in price and marketing, not production. There are eighteen concentrate units in operation in Florida. This year they have greater capacity and in most cases the capacity was available for the entire season. The evaporators operate from 60° to 84° F.

Pilot plant production at the U. S. Citrus Products Station of concentrates made from the same juice at 60°, 70°, and 80° F. showed a flavor difference between the 60° and 80° F. product, but not between 60° and 70° F. samples.

Scott: You can't buy grapefruit concentrate in Texas now - they like it, too.

Keller: Some tangerine frozen concentrate costs $.31 per can against $.22 for orange in California. This is too much of a premium price.

Veldhuis: There is little or no frozen lime concentrate produced in Florida.

Beavens: Lemons will be more extensively processed within a year, possibly 50% of the California crop will be processed.

Keller: Will new concentrate introduced be at the expense of orange concentrate?

von Loesecke: I don't think so. Orange juice is consumed for breakfast, sometimes grapefruit, but grape and apple are usually consumed during the day. Vitamin C in the morning spells orange or grapefruit.

Beavens: Gordon Beisel, Realgold Citrus Products Co., Anaheim, California, says that those buying orange concentrates on the average buy one 6-oz. can per person per month, that is all that is sold. The number of people using frozen concentrate is the same as three years ago and the increased sales are due to repeat business, not wider sales. Probably 1.3% of the population buys frozen citrus concentrate.

Talburt: Snow Crop sells orange concentrate at $.15 per can in the Bay area.

Eskew: I feel that the public is not yet educated to the flavor of grapefruit concentrate, which is the same as fresh juice. They are more familiar with the canned product with its pasteurized flavor.

Veldhuis: Frozen grapefruit concentrate is not going as well as it was hoped it would. The public apparently does not think the difference in quality between frozen and canned grapefruit juice is worth the price.

Scott: Grapefruit concentrate in the stores is not as good as the product I have sampled in plants. We hope to produce a pink colored concentrate from Texas pinks. The problem is one of stabilization of color in the concentrate.

What improvements in quality in frozen concentrates have been made in the past few years? This question was answered in a discussion of other questions.

von Loesecke: What are the true flavoring constituents in citrus concentrates?

Beavens: 25 to 30-ton lots each of Valencia orange and Marsh Seedless grapefruit were secured. 25 tons were handled as fresh juice, 25 tons as freshly pasteurized juice and 25 tons were pasteurized and stored. In each case the juice was stripped. In the water condensates, the water soluble fraction contained methyl alcohol, ethyl alcohol, acetone, acetylaldehyde, formaldehyde, furfural, an acetate ester, hydrogen sulfide and carbon dioxide. We came to the conclusion that the flavor factors in citrus were not in the water fraction.

Beavens and Keller: An ether extraction of the water fraction was made and added to the oil fraction. A 75 percent by volume removal of water was made from the juice which was expressed by commercial extractors and contained oil from the peel. We made ethyl ether extractions of material in dry ice traps and liquid nitrogen traps, and we have separated out twelve or thirteen compounds, after removal of limonene, of molecular size C_8 to C_{15}, which were separated by chromatography using a silicic acid column eluting with ethyl acetate. All flavor contributing constituents are ether-soluble it seems. The distillation was operated at 45-50 mm. vacuum. The water came off at 110° F. and the condenser temperature was 65° F. Liquid nitrogen stops the CO_2 and H_2S.

Phillips, Keller and Eskew discussed the construction of the stripping column to establish the conditions under which the various fractions were collected.

Eskew offered to submit samples of the aqueous phase produced on the essence unit and made the point that it probably contained materials extractable by ether. This was done later.

Keller: The water fraction before extraction contains a faint aroma.

Beavens: There is oil in the sacs of the fruit, which is not soluble in the juice and is not associated with that of the peel. Organoleptically, it appears similar to peel oil and is found in amounts .002 to .003 percent in grapefruit and .004 to .006 percent in Valencia oranges.

Since the amount of oil in the cell sacs is very small, most of the oil commonly present in the cut-back juice must come from the peel and it is from this source that most of the oxygenated constituents that contribute to the characteristic orange flavor are derived. No one of the twelve or thirteen compounds has the complete orange flavor and it appears that the combination of them produces the flavor we recognize as orange.

It is very hard to remove all the limonene by distillation.

Keller: A minimum of .007 percent cold pressed peel oil is necessary for full flavor.

Phillips: Since we are looking for a product that can be stored at room temperature, it would then seem that such constituents as limonene which are subject to deterioration should be removed.

Beavens: It would be expensive to "delimonate" the oil.

Keller: The oxygenated constituents are soluble in 50 percent alcohol at 0° C. leaving the limonene.

_____ What is essence?

Eskew: Essence is "volatile fruit concentrate" and hence is the product obtained by distillation and rectification.

Beavens: The flavor of orange juice is in the oil.

von Loesecke: How can the addition of peel oil be reconciled with Blair's theory? Blair states in part, "The principal factor causing the deterioration in flavor of canned orange juice during storage is the chemical incompatibility of peel oil with the juice."

Beavens: Blair's theory applies for products stored at room temperatures and not necessarily in the frozen state. We can concentrate orange juice to 43° Brix and add a good orange oil and have a product as good as a concentrate made with cut-back. There is no need to recover essence. This is an expensive way of recovering peel oil. The problem is solved simply by adding back a good orange oil.

von Loesecke: Do you know what characteristics are necessary in peel oil to make good oil for flavoring?

Beavens and Keller: Just a good flavored orange oil will serve. Now, not all cold pressed orange oils are suitable. We do not know as yet why this is so or what characteristic makes an oil suitable. There is a great advantage to this procedure. Stopping evaporation at 43° Brix vastly increases the capacity of the evaporator. Above 3-fold heat transfer is greatly retarded. Possibly there is less flavor change in making a concentrate of 43° Brix than when a concentrate of 55 to 60° Brix is made.

Keller: When all removed fractions are returned to the concentrate, which has been produced at 52 to 60° F. with a time of 20-30 minutes, the product does not taste like the original fresh juice. Therefore, the act of processing causes some minor flavor change. The addition of a high quality peel oil to the proper level in the juice gives a product equally as good. When fruit is off-flavored, such as late-season fruit, by adding back oil in quality from other, earlier, fruit the product is up-graded to good quality.

Beavens: Adding back peel oil has been tried before, but quality of the oil had not previously been properly appreciated.

Kew: How do we reconcile the idea of adding oil to get a good flavor with the common observation that the best tasting orange juice is made by hand reaming which has very little oil, usually around .002 percent oil by the Clevenger method.

Beavens and Keller: California hand reamed juice runs around .01 percent oil.

Scott: Hand reamed Texas grapefruit juice runs .005 percent oil, while commercial products will have .02 percent.

Kew: In Florida the canning industry uses deoilers to reduce the peel oil in machine extracted juice. Much orange juice is used by babies and peel oil is an irritant and will cause belching.

Beavens: That is the "burp factor" we recognize.

Keller: The product with added oil is excellent. The amount of oil can be controlled to give a product of any desired oil content to meet a given market. It is easily and economically prepared and is offered as a practical solution. The public accepts products with peel oil. We believe the best flavored product should contain oil in the range of .007 percent to .01 percent.

von Loesecke: Is there any advantage to making essence from grapefruit juice?

Morgan: An essence was produced from grapefruit in Texas which had the characteristic odor, but this odor was lost in water in a few minutes.

Group: We do not know the answer to this question.

von Loesecke: What about grape?

Eskew: At least one producer is adding essence to their frozen concentrate.

von Loesecke: What about tomato concentrate?

Talburt: The Western Regional Research Laboratory is doing some work to identify volatile constituents by solvent extraction. Stripping was done and the recovered material extracted with a solvent.

Keller: The essence was found to have a very objectionable odor.

Talburt: Tomato concentrate is not improved by returning essence.

Eskew: Apparently it is an open question, but probably the essence is of doubtful value.

von Loesecke: What about apple essence?

Eskew: Its value has been demonstrated by commercial practice.

von Loesecke: What about pineapple?

Group: We don't know.

von Loesecke: What is the status of the Western Regional Research Laboratory's steam injection technique and the Eastern Regional Research Laboratory's essence stripping method?

Brown: The steam injection method had three basic advantages:

(1) No heat exchange surface.
(2) It will handle purees.
(3) Speed in heating and cooling.

We plan to make a 4 to 1 concentrate in less than a second. The method is only valuable where the material is heat labile or where heat transfer is a problem. There is no reason otherwise to add water and then remove it. Baby foods or pea soup are examples of products advantageously heated this way. It is necessary to declare "water added as necessary in preparation."

Eskew: There is no disagreement between the Eastern Regional Research Laboratory and the Western Regional Research Laboratory relative to the two types of preheater units developed in the separate laboratories. Each has its own field of use.

Brown: One experimental steam injection unit we use is 3/4" in diameter, 6" long and has an overall heat transfer rate as high as 200,000 B.T.U. per hour. If vacuum cooling is used the essences are removed and must be recovered if volatile flavors are to be returned to the product recovered. We combine the steam injection heater with a tubular vaporizer to form our "combination evaporator." In this unit, we plan to make 4 to 1 concentrates in a total processing time of less than a second. The combination evaporator is remarkably free from fouling of heat transfer surfaces. I have heard of fouling in a Mallorizer unit in a plant in British Columbia processing apple juice to the extent that it must be cleaned out every two hours.

Eskew: Turbulence and a velocity of at least seven feet per sec. travel are essential in preventing fouling of heat transfer tubes with apple juice. No fouling is experienced when these recommendations are followed.

Brown: Mallory's patent (U. S. 2,270,540) states that the "non-fouling" velocity depends on tube diameter.

Phillips: Seven feet or more per second is necessary. Where lower velocities are used fouling does occur. Temperatures above 230° F. should not be used - this is ten pounds steam. Increased temperature increases the rate of coagulation of pectins.

Talburt: Heated apple juice is difficult to clarify.

Eskew: We have had just the opposite experience. Heating, followed by filtration, is a long established method of clarifying.

Veldhuis: Experience in Washington State showed heating complicated subsequent clarification with pectinol.

von Loesecke: What is the significance of Internal Revenue regulations on ethyl alcohol in relation to preparation of fruit concentrates?

Eskew: Since grape juice is aged for several months the juice may contain 1/4 percent alcohol which, when concentrated 4 to 1 and the essence returned, is raised to such a point that it would carry a $9.00 per wine gallon tax. The Bureau might get an expression from the Internal Revenue on this subject. Where sugar is added in the preparation of the frozen grape concentrate, it probably reduces the alcohol to below 1/2 percent.

Beavens: If you simply add oil you don't have to have an Internal Revenue agent around.

von Loesecke: Should the technique of concentration by freezing be considered?

Brown: Commonwealth proposes to produce a concentrate by this method.

Veldhuis: Some attempts have been made in Florida. A plant was built at Haines City, Florida, to freeze by applying high vacuum and then centrifuging. The operation was not profitable, ownership reverted to the R.F.C. and a fire recently wound up affairs.

At Orlando, Florida, Sperti, Inc., has been working with Commonwealth and their process and last year made some concentrate by freezing and centrifuging on a pilot plant scale to test some markets. Nothing has been heard from them this year.

Bissett: Three-fold is as far as concentration can economically be carried by freezing.

von Loesecke: The German process, in which freezing is carried out on a refrigerated drum, has apparently been used successfully in Germany.

Beavens: Entrainment by ice crystals causes losses.

Veldhuis: The flavor of citrus juices is largely associated with the suspended matter and their removal during centrifuging causes loss of flavor.

von Loesecke: Theoretically, isn't it cheaper to freeze out water than to evaporate it?

Phillips: Theoretically, the process should be of interest. About seven times as much energy is required to evaporate a pound of water as is required to freeze it. But considerable mechanical difficulties are encountered.

Talburt: There are interesting possibilities in the German Gümbel process. Essentially the process involves lowering the juice until the desired concentration is obtained and then removing the concentrate by downward displacement.

von Loesecke: Someone representing this process talked to me im Washington sometime ago and left me a photograph of their set-up. This representative was interested in promoting the process in this country, but was doubtful whether processors would feel inclined to junk their present equipment in favor of this new process.

Panel: At present, freezing concentration does not offer much promise with citrus, but developments should be watched. Application to other products should be easier.

von Loesecke: Do we know the optimum conditions of concentration for the more common fruit concentrates?

Panel: Apple - 120° F. is generally used, but temperatures up to 130° F. do not damage it. 26" vacuum is satisfactory.

Veldhuis: Orange - In general, 80° F. or below does not do much damage.

Eskew: Grape - 27" vacuum and 114° F. for 1 hour is probably satisfactory. A little heat seems to improve grape concentrate.

Talburt: 160° F. for 2 hours does not harm it, but at 175° F. damage is shown.

Pineapple - We don't know.

Tomato is not very heat sensitive. In fact, the flavor is improved by heat treatment.

Eskew: Essences of such fruits as strawberry and peach are desirable to add to products like ice cream where it is difficult to give a good flavor with fruit alone and not dilute the cream too much. We should, therefore, also determine the heat tolerance of these juices.

von Loesecke: At what temperatures can citrus concentrates be heated without affecting flavor?

Veldhuis: Commercially, up to 84° F. is used. In the laboratory we recently concentrated the same juice at 60° F., 70° F., and 80° F. We thought we could distinguish between 60° and 80°, but not between 60° and 70° F.

_____ There is interest in inactivating or partially inactivating pectinesterase to stabilize the concentrate. The Florida producers have suffered losses from unstable concentrate that gel or clarify.

Keller: There has been no gelation in California. The Howard triple effect evaporators operate at temperatures of 55°, 65°, and 75° in the various stages.

von Loesecke: What should be done relative to aseptic canning methods?

Veldhuis: Bordo has a pilot plant to try the Martin Process.

Kew: When Mojonnier first installed an evaporator at the Florida Citrus Canners Cooperative in Lake Wales, they were equipped with a special room with tile walls in which the closing machine was set up to aseptically close the concentrate which was cooled with refrigeration after concentration. They were very unhappy about their experience in aseptic filling and installed a pasteurizer.

Eskew: Should we not confine the study of aseptic canning to products that need such a process and not work with those products satisfactorily processed by present methods; e.g., high-density grape and apple concentrates.

von Loesecke: What are the possibilities of obtaining a satisfactory dehydrated orange juice? Would the addition of essence be of value? The R.M.A. Citrus Advisory Committee is not enthusiastic about such a development. They feel that if the Quartermaster Corps wants such a project, they should provide the money to support it. I noticed in the latest Triannual Report that mention was made on the use of a desiccant in packing the dehydrated juice. Perhaps you know that such a process is already patented.

Eskew: What are the problems involved.

Talburt: Problems involved in the preparation of a dehydrated orange juice are (1) caking, (2) browning, and (3) changes in carotenoid pigments during storage that seem to result in formation of a hay flavor and (4) reincorporation of volatile flavors. Browning and caking during storage at 100° F. are greatly reduced by the use of additives such as methocel, corn sirup solids and by in-package desiccation. I know of the patent on in-package desiccation. BHA and packing in an inert atmosphere reduce changes in carotenoid pigments during storage. A sample stored 2-1/2 months at 100° F. has not caked and shows only slight browning. Orange oil may be added to the feed and sufficient oil retained during spray drying to impart satisfactory flavor in the reconstituted juice. Roughly, 2/3 of the cold pressed oil and 1/2 of the terpeneless oil are volatilized during spray drying. We hope to obtain a product with a storage life of at least 6 months at 100° F. For civilian use, a year's storage life at 75° F. is the goal. This should be easier to achieve.

von Loesecke: What are the possibilities and needs of preparing dehydrated fruit juices other than citrus?

Panel: Powdered pineapple, lemon, and grape are interesting possibilities. Cherry might be an interesting subject, for the purpose, for instance, of making jellies or soft drinks by the consumer.

Talburt: The Western Regional Research Laboratory has spray dried apple juice without injurious flavor change other than loss of essence. This constitutes quite a problem if it is to be reincorporated. Corn sirup solids are used as a drying agent.

von Loesecke: What are some of the more important factors affecting storage stability of frozen citrus concentrates? Frozen apple concentrate? Frozen grape concentrate? Frozen tomato concentrate?

Kew: The most important factor affecting storage stability of frozen citrus concentrates is the temperature of storage. The industry recognizes that the amount of pulp is critical and regulates the pulp to 10% or less now. The enzyme activity seems to be the key factor responsible for clarification and gel formation. Experiments are now underway to learn the possibilities of inactivation of the enzymes. In our cooperative study

with Minute Maid Corporation, no change could be measured when the products were stored at zero or below. After a year the samples stored at 5° F. still taste good. At 10° F. storage some change had occurred.

Beavens: In our work, samples were brought to 50° F. for one day, then refrozen. The process was repeated three times and no flavor change could be noted. Samples raised to 70° F. for one day went bad.

Phillips: Is there a difference in storage characteristics of two portions of the same juice concentrated at different evaporator temperatures? Shouldn't we get data on the effect of evaporator temperature?

Veldhuis: Then, as far as we know, citrus concentrates are the only ones benefiting by frozen storage. Cold storage is enough for apple and grape. We do not know about pineapple concentrate.

Eskew: At 35° and at 0°, no detectable difference occurred in 4-fold apple concentrate stored 6 months; at 0° F., it will keep unchanged for a year or more. Relatively high temperatures of evaporation, such as would occur when the vacuum is 26 to 28 inches, has no adverse effect on flavor when high-density apple concentrate is stored at 35° F. At room temperature the concentrates won't keep. These develop a urine-like odor. The higher the acidity of the apple juice, the slower the deterioration at room temperature.

Talburt: The deterioration of a 44° Brix apple concentrate at room temperature was about the same as single strength processed apple juice; deterioration was much slower at 32° F. After 6 months' storage at 100° F., the concentrate was very dark and entirely unacceptable.

Keller: The heat processed low temperature tomato concentrate had a better flavor than the frozen low temperature concentrate.

Beavens: Fluctuating temperatures of storage will be studied in Pasadena and at the Western Regional Research Laboratory.

von Loesecke: What chemical and physical changes take place in citrus concentrates at various temperature levels? In fruit concentrates other than citrus?

Scott: We have been unable to make either grapefruit or orange concentrates from Texas fruit gel in experimental packs during the last two years.

Beavens and Keller: We know of no gelation problem in California citrus other than in navel purees. We need to know what are the chemical changes at elevated temperatures.

Talburt: Aseptic canning may have a place in processing concentrates which would retain quality at elevated storage temperatures.

Veldhuis: On storage at 35° F., we would have to watch for enzymatic changes.

Scott: Brown, what is the status of the steam injection process in regard to the preparation of citrus concentrates?

Brown: Steam injection should be tried with citrus. As yet, it has not been adequately tested. We have been so busy using the steam injection heater and combination evaporator for various pack studies that the engineering problems have not been completely studied; the latter was the purpose for which the unit was built.

Eskew: So far we have not prepared a high Brix, that is 68° Brix, concentrate of apple or grape juice that will keep at room temperature. Both concentrates will keep well at 35° F. They deteriorate more rapidly at room temperature than single strength juice.

Talburt: We have prepared 4-fold apple and grape concentrates that deteriorate at about the same rate as single strength juice.

Panel: Reviewed the work done and in progress on various aspects of the problem such as lipids, pectins, oils, amino acids, flavenoids, carotenoids and enzyme activity. It was also agreed that we know very little at present about the causes of flavor deterioration in concentrates other than citrus.

von Loesecke: What are the chances of obtaining concentrates, particularly citrus, of greater than 30° Brix that can be stored at room temperature? This is important, particularly from the standpoint of the Quartermaster.

Panel generally agreed that the chances of getting a hot concentrate of citrus of from 30° to 40° Brix that is stable at room temperature is doubtful, because of the browning reaction.

Talburt: We could get such a grape concentrate that would be acceptable after 6 months' storage at 70° F.

Beavens: Tomato would make a stable concentrate for 6 months' storage at 70° F., but I am dubious about citrus concentrates.

von Loesecke: What is the sanitary significance of *E. coli* in frozen fruit concentrates?

Patrick: You would have to give the same significance as we now do to *E. coli* in milk.

Phillips: Is there *E. coli* in citrus concentrate?

Patrick: Twenty-four cans were received from the Western Regional Research Laboratory and divided in half. Dr. Faville at the Citrus Experiment Station, Lake Alfred, Florida, examined half of the cans. I found five of the cans contained *E. coli*. Dr. Faville found either six or seven cans with *E. coli*. I have never found it in the commercial Florida product. *E. coli* do not live long in concentrate at zero storage, and have a shorter life at higher temperatures.

Beavens: There is a difference of opinion on identification of *E. coli*.

Patrick: I am using the standard set up by the Committee on Nomenclature of the Society of American Bacteriologists and that identification will be used until such time as it is changed officially.

von Loesecke: I am confused as to what is called E. coli and what is classed as belonging to the coli aerogenes group, or whatever the proper term is, and as I get it some of them don't belong to either class. What do you do with these?

Beavens: Essentially the problem is that some people are "splitters" and some people are "lumpers." Patrick is a "splitter." Woolford has used Patrick's data and would classify 20 of them as E. coli.

von Loesecke: Can E. coli be killed by pasteurization without causing flavor determination?

Panel: It was generally agreed that the organism would die out at pasteurization temperature, but nothing has actually been done in citrus products to support this belief. E. coli would die off rapidly at room temperature, so no pasteurization would be necessary.

von Loesecke: Does heavy microbial contamination cause flavor changes?

Patrick: Yes. If you are going to take the question as stated, yes. (von Loesecke qualified as to temperature and numbers.)

Patrick: Storing juice in cold wall tanks retards the microbial development. At one time this was not done and organisms, predominantly yeasts, caused flavor changes in 20 to 40 minutes. With concentrates, the most serious contamination has come from a kick-back from the condensers due to surging in the evaporators.

Veldhuis: It has been found that in some cases of off-flavor and aroma that often the contamination skips. Cases of good concentrate will be produced intermittently.

Phillips: I question that surging need take place. Any engineering design that would permit kick-back of condenser water in proper operation is a poor one.

Veldhuis: Operation as well as the construction of the evaporators is important. Steam pressure to the jets can vary somewhat. Units with condensers seem to be the worst offender. Proper operation seems to solve the difficulty.

Patrick: Leuconostoc is associated with the off-flavor and aroma. We have been able to make it grow in dilute juice and high populations of these have always been associated with the trouble. We have been able to make it grow in dilute juices and never have been able to make it grow rapidly in concentrates. The off-flavor and aroma must have developed in the condensate and kicked back into the first effect because the organisms never could have grown sufficiently in the time the juice is in the first effect to produce this flavor and aroma.

Keller: There is always entrainment.

Beavens: Most off-flavors in concentrates are associated with kick-back from the condensers and with high incidence of Leuconostoc.

Phillips: It will grow in raw cane juice at 70°, 80°, and 90° F.

Beavens: At 32 to 35° F. we find a decrease in the number of viable organisms in citrus concentrate, while at 38 to 40° F. they will grow. Fluctuating temperatures may contribute to the growth.

von Loesecke: If you have 30,000 organism per cc., would it cause off-flavor?

Patrick: If yeasts are present they will cause flavor change. However, it depends not only on the numbers, but the types present.

von Loesecke: Should we be thinking of a total minimum count in frozen fruit juices? If so, what method should be used for such counts?

Patrick: No. We are interested in types or groups of organisms present, and not so much total count.

Beavens: We must standardize on media and techniques first, after which such specifications might be established.

von Loesecke: What is the tolerance now?

Rushing: The tolerance set forth by one large packer is 100,000 per ml., and I think this is generally accepted in the industry.

von Loesecke: What is the most favorable medium for making the count?

Panel: There is no universally suitable medium.

Beavens: Experience must be accumulated on samples from juice produced with good housekeeping.

von Loesecke: What about fruit juices other than citrus?

Talburt: In our bacteriological work with apples at the Western Regional Research Laboratory we used tryptone glucose extract agar.

von Loesecke: Suppose we found a satisfactory medium for orange, would it be applicable for other fruit juices?

Beavens: It would be necessary to select a medium for each particular product. Industry needs a medium for total count and specific media for differentiation.

Eskew: This discussion seems to apply to citrus only, as other fruit concentrates are pasteurized in the process of essence stripping.

Talburt: There are exceptions as, for example, the freeze concentration of apple juices.

von Loesecke: What progress is being made on direct count methods?

Patrick: No direct count method proposed to date is satisfactory for citrus products. The Stevens Manchester Method worked better with agar than using gelatin on the fixed slide, but the best count obtained was 20,000 per ml. deficient according to the viable count, which I do not consider near enough. The method proposed by Wedding and Sourino has been investigated and proved unsatisfactory. The Vita Stain, which is supposed to stain live tissue, was tried at different pH levels and a variety of temperatures, and on varying amounts of solids in suspension and examined directly. Some orange pulp and yeast cells and some unidentified substances stained. The method was discarded as useless. Fast green was tried in a similar way with the same negative results. Oxidation-reduction tests with indicators, methylene blue, resazurin, proved to be useless because the dyes failed to react indicatively even though the juices were fermenting.

von Loesecke: Could the Howard Mold Count Method be used?

Patrick: Good housekeeping in the citrus plants now has rendered the Howard Mold Count Method useless because one looks for large filaments.

Beavens: It is hard to distinguish between the gunk and the organisms.

von Loesecke: Is it worth-while looking for a direct total count method?

Patrick: It would be a wonderful thing for the industry if one could be developed.

von Loesecke: What is the attitude of public health authorities in Florida, Texas, and California on stream pollution from citrus processing plants?

Veldhuis: The Florida State health authorities are getting more belligerent. They have indicated that they had ample authority to close the plants, but did not intend to do so. The Florida State Health Department wants $50,000 per year to carry on a survey of the canning industry. A bill is now before the Legislature of the State to provide the funds. There is slight chance of it going through. The Florida Canners Association would not provide money. The condensate from evaporators is equivalent to can cooling water. At present there is little reuse of water in canneries. In the State there are some pilot plant trickling filters in use. The new concentrate plant of the Fosgate Cooperative has a small one and Minute Maid Corporation at their Plymouth plant also has an experimental unit. Lakeland Highlands Canning Company has been successfully using a system of running the effluent out on high well-drained land. They periodically rotate the tract. When not in use, such a tract may be successfully farmed. The Snow Crop plant at Dunedin aerates the effluents and then discharges them into the Gulf. You can see from an airplane a dark area in the clear water where the citrus wastes are emptied into the tide-waters. Towns without citrus plants present the same appearance, however.

Scott: The freeze has probably eliminated our waste disposal problems for the next five years. We have had, however, an acute problem. The only natural drainage-way for towns comprising the west half of the Valley carries a stream fed only by domestic and industrial waste, and occasional surface drainage. This stream feeds into Llano Grande Lake, which normally supports considerable marine life. At times of excessive pollution, however, its condition becomes anaerobic, sludge rises, extremely offensive odors are given off, and fish are killed in good numbers. Before flood-control dams were built along the Rio Grande and its tributaries, the lake was flushed out at least once a season with flood water.

Owners of homes adjacent to Llano Grande Lake recently filed suit for damages and injunction against the towns contributing to pollution of the floodway. After passing to the Texas Supreme Court, the suit failed.

Research on methods for handling cannery waste was begun in our laboratory in 1937, and has been carried on intermittently since then by the Texas Department of Health, the Texas and National Canners Associations, and the U. S. Public Health Service. The Texas Department of Health has a laboratory in Weslaco, with a staff of three sanitary engineers, which operates on funds provided by the U. S. Public Health Service, Texas Canners Association, cities and towns of the Valley, and the Department of Health. Activated sludge and trickling filters are being studied, but most promising is lagoon treatment, with sufficient nitrate to support algae.

Veldhuis: McNary, a Citrus Commission Fellow, has a methane pilot plant near Winter Haven, Florida. He now seems to have a fermentation that will go. A yeast fermentation now precedes the anaerobic fermentation and removes the peel oil presumably that heretofore has prevented the proper methane fermentation.

Scott: Our laboratory has cooperated with various efforts in Texas, but has never been asked to conduct any research on the project. Neither wells nor irrigation can be used as a means of disposal.

Keller: It is said that there is no problem in California. The practice around Los Angeles is to dump the effluent into the city sewer. Suspended solids are screened and the pH adjusted to 6.5.

The plants not on the city sewer system have successfully lagooned the effluents on several hundred acres of land. The part being used is rotated and the rest is rented to farmers. The Corona and Ontario plants use lagooning.

von Loesecke: Should we undertake research in this field?

Panel: Since the U. S. Public Health Service has funds for this work, they should be the ones to undertake this work. We have no authority to enter any plant except with the permission of the owners, but could cooperate with these agencies.